

Atlas of the Lunar Terminator

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PUBLISHED BY THE PRESS SYNDICATE OF THE UNIVERSITY OF CAMBRIDGE
The Pitt Building, Trumpington Street, Cambridge, United Kingdom

CAMBRIDGE UNIVERSITY PRESS
The Edinburgh Building, Cambridge CB2 2RU, UK www.cup.cam.ac.uk
40 West 20th Street, New York, ny 10011-4211, USA www.cup.org
10 Stamford Road, Oakleigh, Melbourne 3166, Australia
Ruiz de Alarcón 13, 28014 Madrid, Spain

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First published 2000

Printed in the United Kingdom at the University Press, Cambridge

Typeset by the Author in QuarkXPress®

A catalogue record for this book is available from the British Library

Library of Congress Cataloguing in Publication data

Self-organized biological dynamics and nonlinear control: exploring biological
complexity, stochasticity, chaos, and electromagnetic interactions in cell signaling
systems/edited by Jan Walleczek.

p. cm.

Includes index.

ISBN 0 521 624336 3 (hb)

1. Cellular signal transduction. 2. Self-organizing systems. 3. Nonlinear systems.

I. Walleczek, Jan, 1964-

QP517.C45 S45 2000

571.6-dc21 99-044949

ISBN 0 521 59002 7 hardback

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SECTION II. ATLAS

Arrangement of the Atlas

The CCD image mosaics in this section show the Moon at 47 different phases, arranged in ascending order of colongitude (291° - 357° , 003° - 247°) from waxing crescent to waning crescent. North is at the top in all views. Each phase begins with a page that describes selected features best seen under that lighting. The top margin of the descriptive page lists the telescopic, lighting, and topocentric libration conditions of the mosaic. Accompanying the descriptive text are one or more large-scale CCD images of selected features. Following this page is the CCD image mosaic, shown in two or three sections arranged in north-to-south order, with the latitude range and scale given on each section. For example, the view at colongitude $067^{\circ}.2$ is titled simply "Colongitude 067° ." Its descriptive page includes enlarged views of two selected lunar areas then visible. Its three mosaic pages are labeled " 067° -N" (north), " 067° -C" (central), and " 067° -S" (south).

Each mosaic section includes an inset that gives the names of the formations that appear in the image. In addition, on pages 269-288 is an overall index of named formations, divided into craters and non-crater features. The index gives features' longitudes and latitudes and the colongitude mosaics on which they appear. For craters, diameters and depths are also given. On pages 59 and 60 are two lunar index maps that show the position of the terminator for each mosaic; the first map for the waxing Moon (Figure II.1) and the second for the waning Moon (Figure II.2). In addition to colongitude, the effect of varying selenocentric solar declination has been taken into account in plotting the terminator positions, so that the terminator arcs do not intersect neatly at the poles, as would be the case if they always followed meridians.

Making the Mosaics

Chapter 1 has described the general process of obtaining individual CCD images. However, one image does not make a mosaic, so it is pertinent here to describe how images intended for mosaics are acquired, processed, and then assembled.

A series of images that are to be mosaiced must be as uniform as possible; this means no changes in the exposure time, camera orientation, optical system, or filter (or lack of filter) can occur while the series is being exposed. Any cloudiness, even thin clouds, is usually fatal because the Moon's brightness will change between images. Indeed, if the Moon is at a low altitude, the series must be completed quickly because the transparency even of the clear atmosphere will change rapidly. Another reason not to dawdle excessively is that the colongitude changes by a tenth of a degree every 11-12 minutes.

The writer's procedure is to begin each series at the northern limb, then to expose frames successively southward along the terminator until he reaches the southern limb. The exposure time is adjusted by trial and error so that features 8° - 10° from the terminator are on the point of "saturation" (overexposure), to ensure continuity with the previous and subsequent mosaics. Naturally, it is important to be sure that each frame overlaps its neighbors; preferably by 10-20 percent. Depending on the telescope used, the amplification, if any, and the lunar phase and distance, the terminator strip will constitute approximately 12-30 images, and take 20-40 minutes to acquire. Because of seeing changes, the writer frequently exposes several (or many!) frames of an area before he finds one worth being saved to disk.

The lunar images are initially stored on the disk drive of a Macintosh IIsi computer that is dedicated to acquiring CCD images. At the end of an observing session, the images acquired are transferred to floppy disks and read into the disk drive to the writer's "indoor" computer, currently

a Macintosh 8600/250. This more powerful computer is used to process the images, which begins with performing a linear “stretch” of their contrast with the software supplied by SpectraSource, the manufacturer of the CCD camera. First, the DN values (brightness levels in a range 0-65,520) of the darkest and the brightest pixels in each frame are determined. Then, the contrast of each frame is “stretched” so that its darkest pixel is set to a DN (brightness value) of 0. A brightness range is calculated so that the frame with the highest initial DN for its brightest pixel has its brightest pixel set to a DN of 65,520 (the camera’s highest possible DN). This ensures that the maximum stretching for each frame is achieved consistent with every frame’s contrast being exaggerated by a uniform amount.

At this point, the images are converted to PICT-format files using the Macintosh “screen copy” function. This allows them to be read by the Photoshop image processing program (the writer began with Version 2.5 and is now using Version 5.0). All of the frames are placed on one Photoshop image. Then a non-linear contrast stretch is used to selectively exaggerate brightness near the terminator. Next, each of the individual frames is selected and moved to fit the previous frame, again proceeding in a north-to-south order. The successive frames are fitted by eye, matching detail along their edges; with aerial photographs, this would be called an “uncontrolled mosaic.” (An experiment in measuring the positions in ten selected mosaics indicated that this “eye-balling” process created a median scale error of just 0.4 percent, more than sufficient for pictorial purposes, if not for precise measurement.)

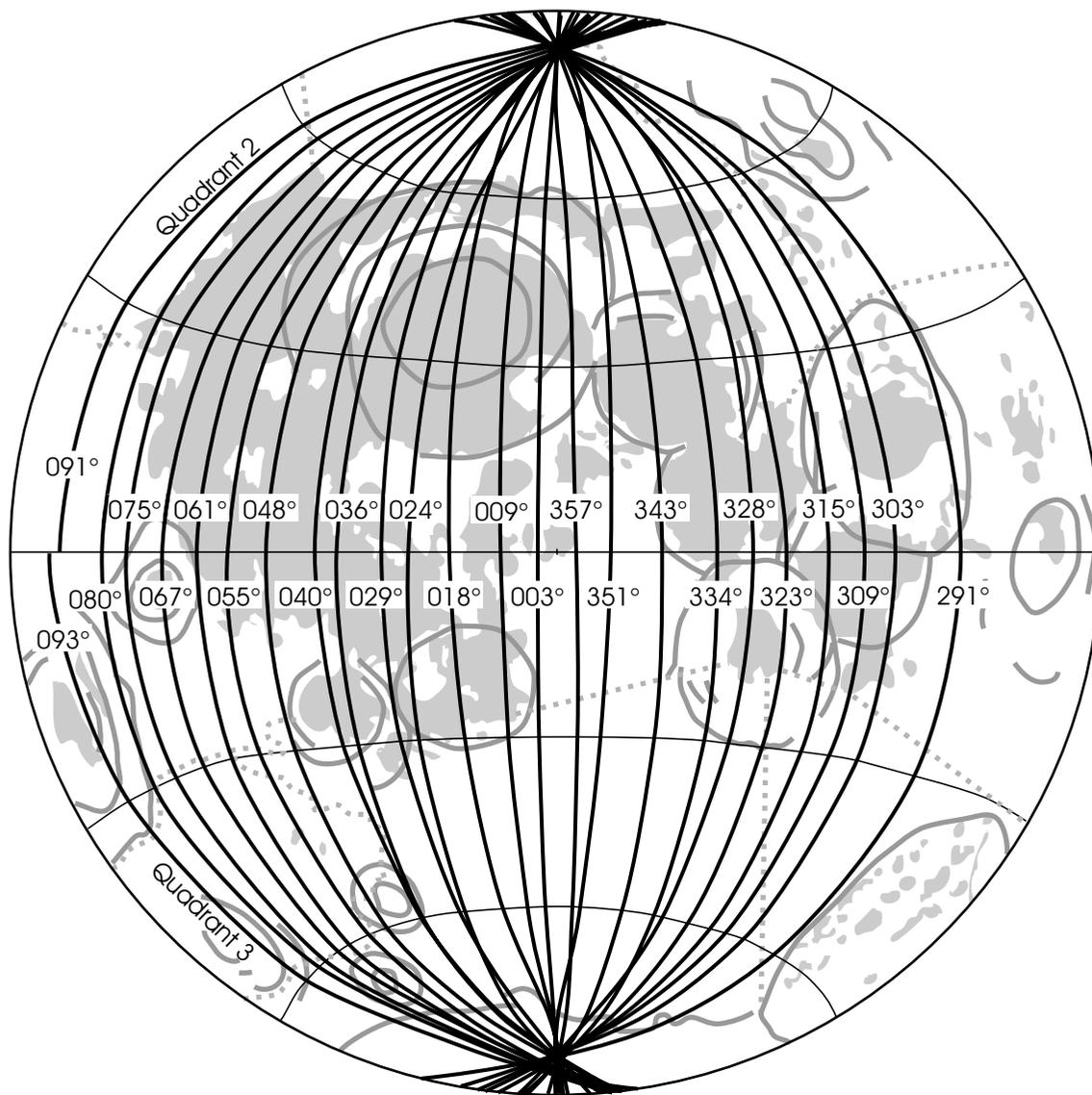
Despite exercising all the care possible, there may remain visible breaks between occasional frames. For example, feature positions may disagree slightly because of short-term differences in seeing. Also, brightness levels may differ due to differences in the exposure time of the camera’s mechanical shutter, to short-term variations in atmospheric transparency, or to both. Small-scale differences at the frame edge can be obscured by judicious use of Photoshop’s “smudge” tool; inter-frame brightness differences are reduced by using a slight amount of further contrast stretching on individual troublesome frames; fortunately this is rarely necessary.

Once the frames are all assembled, and edge-to-edge differences reduced as much as possible, a black fill is used for the areas behind the terminator or beyond the limb. This prepares the mosaic for unsharp masking, which must be employed to the entire mosaic in a single step because the process can create “artifacts” (bands of dark or light shading) along the margin of the area of application. The writer typically uses high levels of unsharp masking which creates “grain” in areas of uniform shading; this is removed using the program’s “despeckle” function.

The processing of all images in a mosaic must be identical in terms of contrast stretching and sharpening, just as for their initial exposure. This means that all the adjustments employed are compromises intended to give the best results for the mosaic as a whole. Were the individual frames exposed and enhanced singly, they often would appear better-exposed and more clearly defined than they do in the mosaic. Unfortunately, were such a procedure followed, it would result in obvious breaks between frames in the resulting mosaic.

Although the writer tries to expose the frames so that their narrow dimension is aligned with lunar north-south, the mosaic may show some inclination to the lunar axis. If this misalignment exceeds one degree, the writer uses Photoshop’s “rotate” command to correct. At this point the mosaic is essentially completed. However, the scales of those mosaics used in this atlas have been adjusted, and each mosaic divided into two or three segments, in order better to fit the pages.

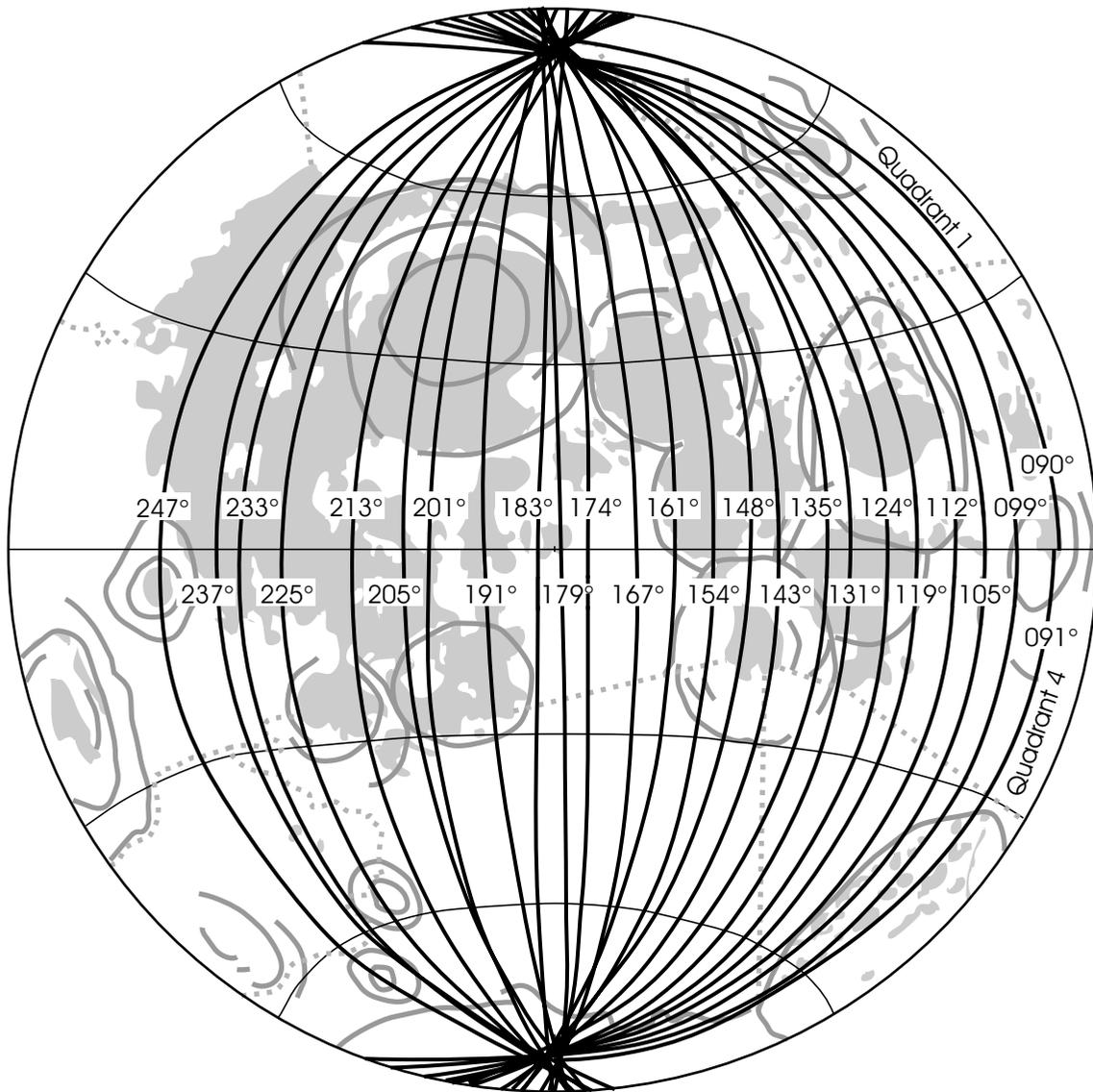
Terminator Position Index: Waxing Moon



Values represent colongitude.
Illumination is from the right.
Lambert Equal-Area Projection, centered on mean disk center
and extending 100° from center.

Figure II.1. Terminator position index for colongitude mosaics, waxing Moon.

Terminator Position Index: Waning Moon



Values represent colongitude.
Illumination is from the left.
Lambert Equal-Area Projection, centered on mean disk center
and extending 100° from center.

Figure II.2. Terminator position index for colongitude mosaics, waning Moon.